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Assemblage of squamate reptiles in a natural remnant of Cerrado in southern Minas Gerais, Brazil

Priscila Silva Lucas[1, 4*], **Iara Alves Novelli**[1, 2] and **Bernadete Maria de Sousa**[1, 3]

1 Laboratório de Herpetologia, Departamento de Zoologia, Instituto de Ciências Biológicas, Universidade Federal de Juiz de Fora, CEP 36036-900, Martelos, Juiz de Fora, MG, Brazil
2 Bolsista da Capes no PNPD vinculada ao Programa de Pós-Graduação em Ciências Biológicas: Comportamento e Biologia Animal da UFJF
3 Bolsista CNPq – Brazil
4 Present address: Centro Brasileiro de Estudos em Ecologia de Estradas, Departamento de Biologia, Universidade Federal de Lavras, Lavras, MG, 37200-000, Brazil
* Corresponding author. E-mail: prilucass@gmail.com

Abstract: Considered one of the most threatened biomes, the Cerrado currently has more than half of its original area converted into other types of land-use and little is known about the reptiles inhabiting this biome in Minas Gerais state. We quantified the species richness of Squamata and assessed the faunal composition in the Reserva Biológica Unilavras – Boqueirão. We recorded six snake species and 10 lizard species in the various physiognomies. The highest species richness was observed in the gallery forest, followed by the cerrado *sensu stricto* and rupestrian fields. Gallery forest and cerrado *sensu stricto* had similar compositions. The rarefaction curves suggest it is possible that other species may occur in the study area as well as new occurrence records of some species and the distribution expansion of others for this biome in Minas Gerais.

Key words: diversity; lizards; richness; snakes

INTRODUCTION

Squamates are the most diverse and specious of living reptiles (Vitt and Caldwell 2009) with 10.272 species (Uetz & Hošek 2015). The snake fauna of the Neotropical region is characterized by high species richness and complexity of ecological interrelationships (Henderson et al. 1979; Duellman 1989; Cadle and Greene 1993). Research regarding squamate diversity in Cerrado areas has intensified in the last decade, focused mostly on the Cerrado's core region in central Brazil (e.g., Colli et al. 2002; Nogueira et al. 2005; 2009; Valdujo et al. 2009; Recorder et al. 2011). Other relevant studies are Vanzolini (1948), Sawaya et al. (2008) and Araújo et al. (2010) in Cerrado remnants at the São Paulo state and Gainsbury and Colli (2003), França et al. (2006) and Mesquita et al. (2006, 2007) in enclaves of Amazonian savannas in the states of Amapá, Amazonas, Pará, Rondônia and Roraima.

In Minas Gerais state, many of the surveys and studies that address the local composition and diversity are from areas of Atlantic Forest (Feio and Caramaschi 2002; Costa et al. 2009, 2010; Sousa et al. 2012) and its transition to Cerrado (Bertoluci et al. 2009; São-Pedro and Pires 2009; Silveira et al. 2010; Sousa et al. 2010, Cruz et al. 2014). The Cerrado areas, which once occupied approximately 57% of the state, are currently in process of rapid transformation (Drummond et al. 2009) and despite the potential richness in the biome (Recorder and Nogueira 2007; Novelli et al. 2012), a geographically widespread and systematic sampling has not been performed in these areas.

Besides records of some species distributions (Santos et al. 2009; Novelli et al. 2011), studies on reptiles in the Cerrado of Minas Gerais that addressed aspects of diversity and conservation were those of Brites and Bauab (1988), Assis (1999), Recorder and Nogueira (2007), Mesquita et al. (2007), Sousa et al. (2010), Novelli et al. (2012) and Costa et al. (2014). This study aimed to survey the fauna of Squamata in southern Minas Gerais, determining the composition and species richness in different physiognomies of the area.

MATERIAL AND METHOD

Sampling was carried out in three physiognomies: cerrado *sensu stricto*, rupestrian fields and gallery forest (Pereira and Volpato 2005) (Table 1) in the Reserva

Table 1: Sampling physiognomies in southern Minas Gerais, Brazil. PTDF: pitfall traps and drift fences. TCS = time-constrained search. CE = casual encounters.

Physiognomy	Geographic coordinates	Sampling technique
Cerrado *sensu stricto*	21°50′51″ S, 044°59′58″ W	PTDF, TCS, CE
Gallery forest	21°20′48″ S, 044°59′49″ W	PTDF, TCS, CE
Rupestrian fields	21°20′50″ S, 044°59′21″ W	TCS, CE

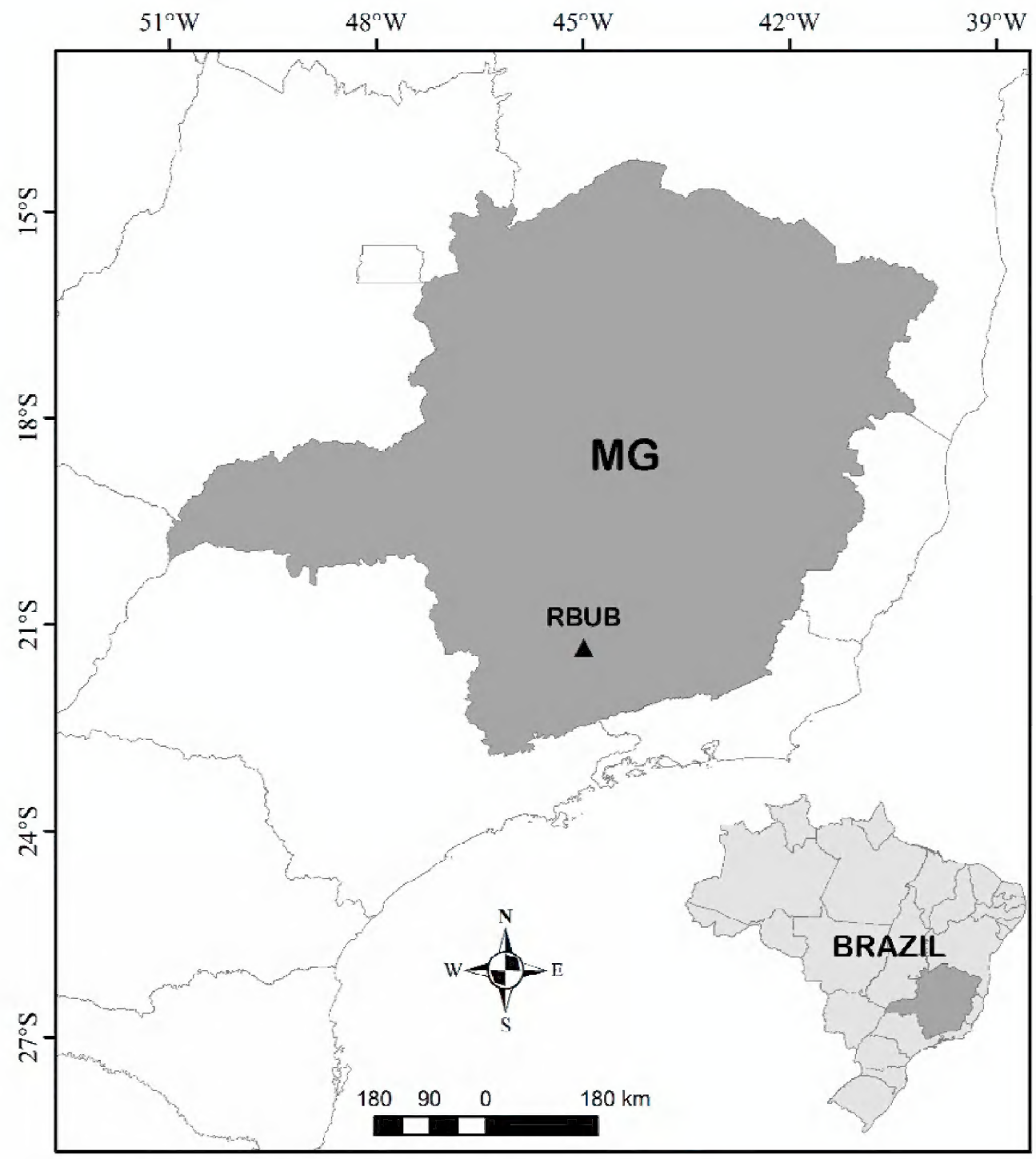

Figure 1. Map with the location of Reserva Biológica Unilavras – Boqueirão (RBUB), state of Minas Gerais (MG), Brazil.

Biológica Unilavras Boqueirão, municipality of Ingaí, Minas Gerais state (Figure 1) (see Novelli et al. 2012 for full study site description). Samples were obtained during from November 2010 to November 2011, at least once per week. We used pitfall traps and drift fences (PTDF), time-constrained search (TCS) and casual encounters (CE). The PTDF was installed according to Cechin and Martins (2000) and equally distributed between cerrado *sensu stricto* and gallery forest. The traps were composed of buried 30 L buckets interconnected by fences with 50 cm in height, plus 10 cm buried in the soil. Each line had four buckets, 6 m apart. Three parallel lines, 6 m apart, formed a set of traps.

In each physiognomy (cerrado *sensu stricto* and gallery forest) three sets of traps were installed, totaling 36 buckets, with a minimum distance of 30 m between sets. Due to the composition of the soil and great number of stones in the rupestrian fields, this method was impractical in this physiognomy. A sampling effort of 1,548 pitfall trap-days was carried out in gallery forest; however, because of a fire that destroyed the traps in the cerrado *sensu stricto* in October 2011, only 1,332 pitfall trap-days was conducted in this physiognomy, making a total of 2,280 pitfall trap-days. Time-constrained searches (TCS) were performed by two observers during the day, at the same sites at which the pitfall traps were installed. Total TCS effort at RBUB was 180 hours. Casual encounters (CE) consisted of encountering specimens during other activities, such as travel between study areas when no other sampling was being carried out (e.g., Sawaya et al. 2008).

Voucher specimens were deposited at the Coleção Herpetológica da Universidade Federal de Juiz de Fora (CHUFJF) and Coleção de Répteis do Laboratório de Zoologia (CRLZ) of Centro Universitário de Lavras - Unilavras. All specimens were collected with permits from the Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renováveis-IBAMA/SISBIO, Nº 24661-1 and Nº 17917-1. We followed Costa and Bérnils (2015) for taxonomic arrangement in this study.

To estimate the species richness in each physiognomy, species rarefaction (sample based) curves were constructed from the average of 1,000 randomizations generated by the program EstimateS V. 8.2.0 (Colwell 2006), using the non-parametric estimator *Jackknife 1* for specimens recorded using PTDF and TCS. This is an index based on the incidence, i.e., the number of species in a given sample, quantifying the estimate based on rare species (Dias 2004; Magurran 2004). To determine similarities of species compositions among physiognomies,

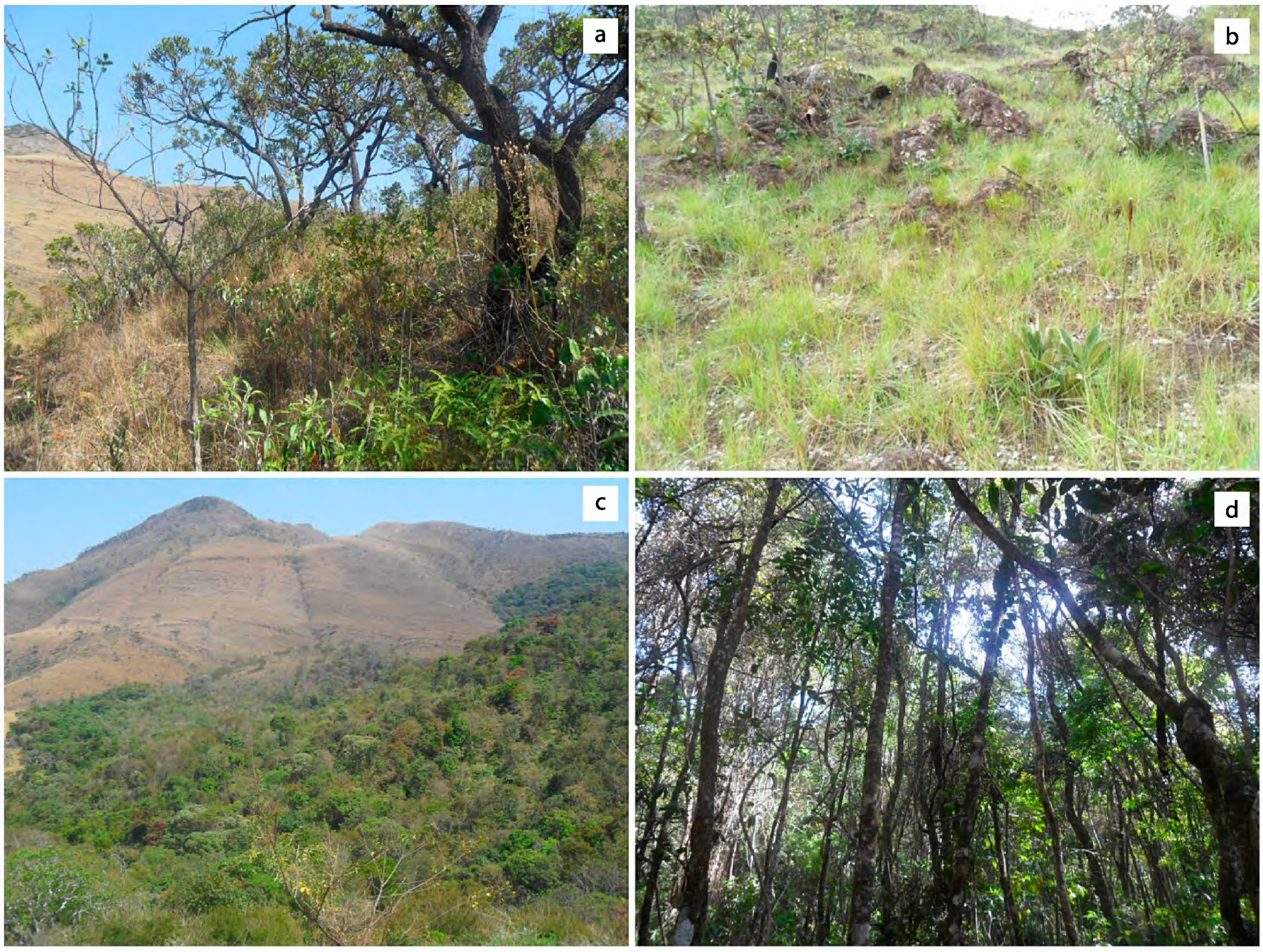

Figure 2. Physiognomies at Reserva Biológica Unilavras - Boqueirão, Ingaí, Minas Gerais, Brazil. **a**) Cerrado *sensu stricto*. **b**) Rupestrian fields. **c**) Aerial view of Gallery forest. **d**) Gallery forest inside view. Photos: PSL.

cluster analyses were performed by the UPGMA method, using the modified index of similarity of Morisita-Horn (Magurran 2004; Recorder and Nogueira 2007).

RESULTS

We recorded 16 species of Squamata: 10 species of lizards and six of snakes in eight families (Table 2; Figure 3). The physiognomy with the highest species richness and number of individuals was the gallery forest with 10 species and 21 specimens, followed by cerrado *sensu stricto* with seven species and 21 specimens and rupestrian fields with four species and 18 specimens. PTDF collected the greatest number of species and individuals, followed by TCS and CE (Table 2).

The species richness estimated by the *Jackknife 1* index for the three physiognomies together was 23.81 species (Figure 4). The same estimator for physiognomies separately revealed a species richness of 15.86 for gallery forest, 7.92 for the cerrado *sensu stricto* and 5.95 for the rupestrian fields. The rarefaction curves constructed based on the estimation of total species richness and in each physiognomy show no tendency to stabilization (Figure 4).

The cluster analysis (Figure 5) revealed a faunal separation between rupestrian fields and other physiognomies. Gallery forest and cerrado *sensu stricto* showed the greatest similarity (CM = 0.45) sharing four species (the lizards *Ophiodes striatus*, *Enyalius bilineatus*, *Urostrophus vautieri* and *Aspronema dorsivittatum*). Cerrado *sensu stricto* and rupestrian fields shared only one species (the snake *Crotalus durissus*). No species were shared between gallery forest and rupestrian fields. The gallery forest contained six species not found elsewhere (the lizards *Cercosaura ocellata*, *Heterodactylus imbricatus*, *Notomabuya frenata* and the snakes *Erythrolamprus aesculapii*, *Spilotes pullatus* and *Bothrops neuwiedi*). The rupestrian fields contained three species not collected elsewhere (the lizards *Ameivula ocellifera* and *Tropidurus itambere* and the snake *Sibynomorphus mikanii*). The cerrado *sensu stricto* presented two species not found elsewhere (the lizard *Ameiva ameiva* and the snake *Erythrolamprus almadensis*).

DISCUSSION

Observed total species richness (16 species) corresponds to 17.5% of lizard species and 4.3% of

Table 2. Sampled areas and life habit of the species of Squamata in three Cerrado physiognomies of the Reserva Biológica Unilavras, Boqueirão, Ingaí, Brazil. In brackets the number of captures (N) in each physiognomy. CSS = cerrado *stricto sensu*; GF = gallery forest and RF = rock fields. Sampling technique (number of individuals recorded). PTDF: pitfall traps and drift fences. TCS = time-constrained search. CE = casual encounters. FLL: forest leaf litter. SG: sandy ground. DR: dirty road. HV: herbaceous vegetation. RO: rock outcrop.

Taxon	Physiognomy (N)	Sampling technique	Substrate type
Suborder Serpentes			
Family Colubridae			
Spilotes pullatus (Linnaeus, 1758)	GF(1)	CE(1)	FLL
Family Dipsadidae			
Erythrolamprus aesculapii (Linnaeus, 1766)	GF(2)	PTDF(1), TCS(1)	FLL
Erythrolamprus almadensis (Wagler, 1824)	CSS (1)	PTDF(1)	SG
Sibynomorphus mikanii (Schlegel, 1837)	RF(1)	CE(1)	DR
Family Viperidae			
Crotalus durissus Linnaeus, 1758	CSS (2), RF (1)	TCS(2), CE(1)	SG
Bothrops neuwiedi Wagler, 1824	GF (1)	TCS(1)	FLL
Suborder Sauria			
Family Anguidae			
Ophiodes striatus (Spix, 1825)	CSS (2), GF (5)	PTDF(5), CE(2)	FLL, SG
Family Gymnophthalmidae			
Cercosaura ocellata Wagler, 1830	GF (1)	PTDF(1)	FLL
Heterodactylus imbricatus Spix, 1825	GF (2)	PTDF(2)	FLL
Family Leiosauridae			
Enyalius bilineatus Duméril & Bibron, 1837	CSS (10), GF (1)	PTDF(8), CE(3)	SG, HV
Urostrophus vautieri Duméril & Bibron, 1837	CSS (1), GF (1)	PTDF(2)	FLL, SG
Family Mabuyidae			
Aspronema dorsivittatum (Cope, 1862)	CSS (4), GF (6)	PTDF(9), TCS(1)	FLL, SG
Notomabuya frenata (Cope, 1862)	GF (1)	PTDF(1)	FLL
Family Teiidae			
Ameiva ameiva (Linnaeus, 1758)	CSS (1)	PTDF(1)	SG
Ameivula ocellifera (Spix, 1825)	RF (4)	TCS(3), CE(1)	SG
Family Tropiduridae			
Tropidurus itambere Rodrigues, 1987	RF (12)	TCS(10), CE(2)	RO

snake species recorded for Minas Gerais (Bérnils et al. 2009). Nevertheless, the species richness estimated by the *Jackknife 1* and the ascendant rarefaction curves indicate the likely occurrence of other species in the RBUB. A study of the lizard fauna within the RBUB done by Novelli et al. (2012) found 10 species, although in other sampling sites than those in this study. Of these 10 species, only *Polychrus acutirostris* was not collected in this study, and the species *Ameivula ocellifera* was collected for the first time in this study. Some species of snakes that were not recorded in this study, but which were reported in previous studies and deposited in the CRLZ are *Atractus pantostictus*, *Philodryas patagoniensis* and *Xenodon merremii*. For the RBUB a total of 20 squamate reptile species are known, a similar result for the potential species richness of Squamata in Brazilian Cerrado compared with other areas. In Minas Gerais several studies have been done in this biome and the local squamate species richness can vary: Mesquita et al. (2007) 16 species, Record and Nogueira (2007) 29 species, Bertoluci et al. (2009) 16 species, São Pedro and Pires (2009) 28 species, and Sousa et al. (2010) with 29 species. Sampling design could also affect the number of species reported. Pitfalls with a "Y" design usually sample more species and specimens than an "I" design (Ribeiro Jr. et al. 2011). Another factor is the drift fence material; in Cerrado the plastic material is not resistant to exposure over time without damage (personal observation). This could affect the effectiveness of this method. Furthermore, it is possible that other methods, such as records by local residents, could increase the knowledge of squamate species for the RBUB, as shown in other areas (Cechin and Marins 2000).

The general pattern observed for the Cerrado predicts that savanna physiognomies harbor greater species richness and abundance than forested physiognomies (Brandão and Araújo 2001; Nogueira et al. 2005, 2009, 2011). However, this study found the highest species richness in the gallery forest. According to Ricklefs and Schutler (1993) based on the theory of structural complexity, habitats such as tropical forests were rich in species due to greater vertical structural complexity and productivity that would result in greater supply and variety of microhabitats and prey, allowing niche specializations and thus avoiding competition. In terms of species richness in Cerrado areas, gallery forests usually exhibit low numbers at most sites (Anacleto 2004; Recorder and Nogueira 2007; Vaz-Silva et al. 2007; Valdujo et al. 2009; Araújo et al. 2010; Recorder et al. 2011), compared to other savanna physiognomies that

Figure 3. Squamata species recorded from Reserva Biológica Unilavras - Boqueirão, Ingaí, Minas Gerais, Brazil: **a**) *Ophiodes striatus*, **b**) *Cercosaura ocellata*, **c**) *Heterodactylus imbricatus*, **d**) *Enyalius bilineatus*, **e**) *Urostrophus vautieri*, **f**) *Aspronema dorsivittatum*, **g**) *Notomabuya frenata*, **h**) *Ameiva ameiva*, **i**) *Ameivula ocellifera*, **j**) *Tropidurus itambere*, **k**) *Erythrolamprus aesculapii*, **l**) *Erythrolamprus almadensis*, **m**) *Sibynomorphus mikanii*, **n**) *Spilotes pullatus*, **o**) *Bothrops neuwiedi*, **p**) *Crotalus durissus*. All photos were done by the first author, except n) and p) done by Fernando Antônio Frieiro-Costa.

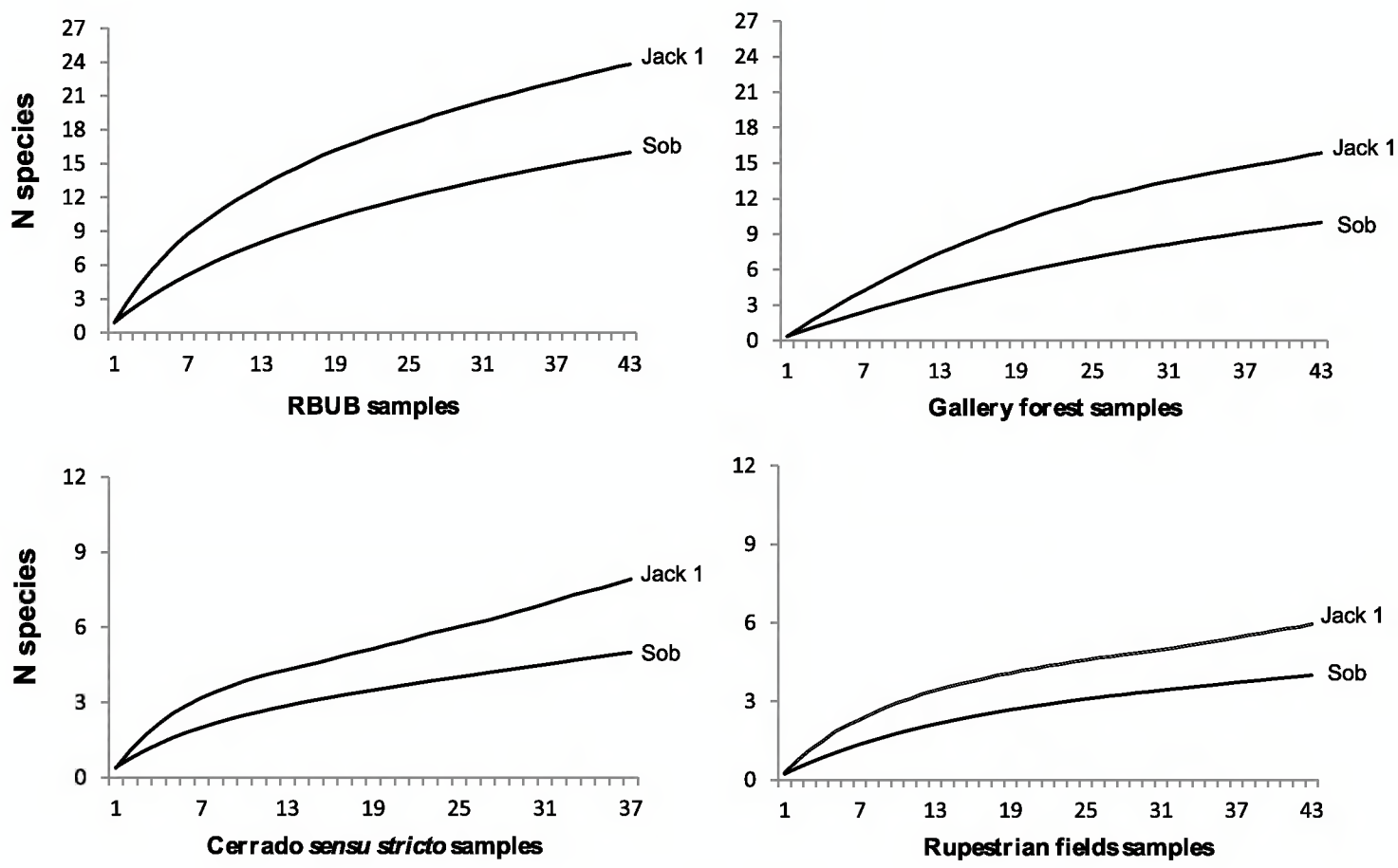

Figure 4. Rarefaction curves of species based on *Jacknife 1* and the observed species richness (Sob) from Reserva Biológica Unilavras- Boqueirão, Ingaí, Minas Gerais, Brazil. N species = number of species, RF = rupestrian fields, GF = gallery forest, CSS = cerrado *sensu stricto* and RBUB = Reserva Biológica Unilavras-Boqueirão.

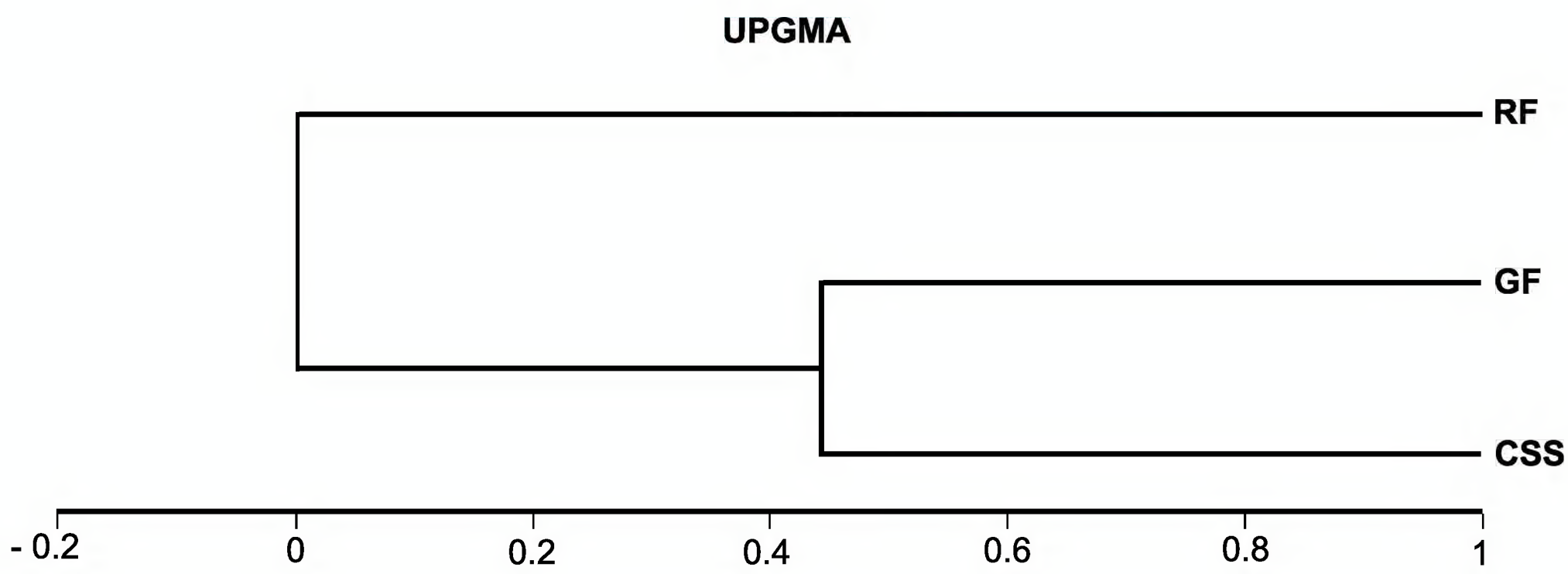

Figure 5. Similarity based on the modified index Morisita-Horn of the three Cerrado physiognomies in the Reserva Biológica Unilavras - Boqueirão, Ingaí, Minas Gerais, Brazil. RF = rupestrian fields, GF = gallery forest and CSS = cerrado *sensu stricto*.

dominate the landscape (Nogueira et al. 2009). However, because gallery forest is the predominant habitat in the RBUB (52.5% of the total area of the reserve) it is probable that greater species richness for this physiognomy could be directly related to the larger size of the area (species-area effect) (Losos and Schluter 2000).

We recorded some species of Squamata that preferentially inhabit Cerrado forest, such as the snake *Erythrolamprus aesculapii* (França et al. 2008; França and Braz 2013) and the lizards *Heterodactylus imbricatus* (Dixo and Verdade 2006) and *Urostrophus vautieri* (Santos et al. 2009; Souza Filho 2011). Some species prefer gallery forests and the records suggest that they use these areas simply because they are present in the Cerrado biome. As shown, most records from gallery forest are of generalist and savannah species that occasionally visit forest, such as the lizards *Notomabuya frenata*, *Cercosaura ocellata* (Recorder and Nogueira 2007; Araújo and Almeida-Santos 2011), *Ophiodes striatus* (Valdujo et al. 2009; Novelli et al. 2012), *Aspronema dorsivittatum* (Vaz-Silva et al. 2007) and *Enyalis bilineatus* (Sousa et al. 2010; Novelli et al. 2012). These species also exhibit similar abundance in both physiognomies in the region, as shown by this work and the previous study by Novelli et al. (2012). Species typical of open areas in Cerrado, such as the snake *Bothrops neuwiedi* (Borges and Araújo 1998), in this study were found only in gallery forest and not in either cerrado *sensu stricto* nor rupestrian formations. This may be because forests in RBUB contain natural sunlit gaps that may attract some heliothermic savannah species (Werneck 2004; Macedo et al. 2008). The locations richest in species are closer to the areas of "core" Cerrado in central Brazil, increasing opportunity for immigration (Gainsbury and Colli 2003; Nogueira et al. 2009). In contrast, more peripheral and isolated enclaves of Cerrado, such as RBUB, tend to have lower species richness (Gainsbury and Colli 2003; Nogueira et al. 2009; Araújo et al. 2010).

Gallery forest and cerrado *sensu stricto* were most similar in fauna composition, sharing four species according to Morisita-Horn index. Rodrigues (2005) stated that gallery forests do not support species not found elsewhere if there is great fauna exchange with open formations in the Cerrado, as we observed here for *Ophiodes striatus*, *Enyalius bilineatus*, *Urostrophus vautieri* and *Aspronema dorsivittatum*. The rupestrian formations are often overlooked in sampling herpetofauna due to sampling limitations. Most herpetofaunal studies performed in rupestrian formations in the Cerrado address topics such as diet and activity patterns and microhabitat use (Van Sluys et al. 2004; Ribeiro et al. 2009; Filogônio et al. 2010), reproduction (Galdino et al. 2003) and only rarely the composition and abundance of reptile fauna (Rocha and Prudente 2010). Thus this study contributes to the knowledge of the fauna of these often ignored Cerrado formations.

No species found are on the Brazilian list of threatened species (MMA, 2014) and only *Tropidurus itambere* is endemic to this biome (Nogueira 2010). The species richness in the RBUB is well represent by lizards and some snakes, but other sampling techniques will be necessary to properly evaluate the richness composition, especially of fossorial snakes and amphisbaenians. This area also shows potential for new records of some species and the distribution expansion of species such as *Urostrophus vautieri* (Santos et al. 2009) and *Heterodactylus imbricatus* (Novelli et al. 2011), previously unknown for this biome.

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